

AD-A095 106

NAVAL TRAINING EQUIPMENT CENTER ORLANDO FL  
FRONT-END ANALYSIS: GENERIC AND NONGENERIC MODELS. (U)  
SEP 80 B E MULLIGAN, J F FUNARO

F/G 9/2

UNCLASSIFIED

NAVTRAEGUIPC-IH-325

NL

AD  
A095106

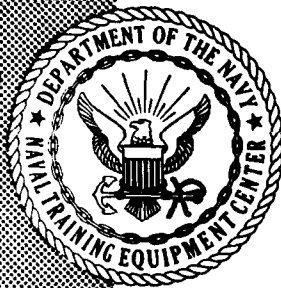
END

DATE

FILED

11 3 1981

DTIC



LEVEL

12

TECHNICAL REPORT: NAVTRAEQUIPCEN IH-325

FRONT-END ANALYSIS: GENERIC AND NONGENERIC MODELS

B. E. Mulligan, Ph.D.  
Visiting Professor, Code N82  
Naval Training Equipment Center  
(Department of Psychology  
University of Georgia  
Athens, Georgia 30602)

DTIC  
FEB 17 1981  
C

and

J. F. Funaro, CDR  
Director, Plans, Programs, and Analysis Department  
Naval Training Equipment Center  
Orlando, Florida 31813

September, 1980

DoD Distribution Statement

Approved for public release;  
distribution unlimited.

NAVAL TRAINING EQUIPMENT CENTER  
ORLANDO, FLORIDA 32813

81 2 17 009

Technical Report: NAVTRAEQUIPCEN IH-325

FRONT-END ANALYSIS: GENERIC AND NONGENERIC MODELS

B. E. MULLIGAN, Ph.D.  
Visiting Professor, Code N82  
University of Georgia

and

J. F. FUNARO, CDR  
Director, Plans, Programs, and Analysis Department

September 1980

GOVERNMENT RIGHTS IN DATA STATEMENT

Reproduction of this publication in  
whole or in part is permitted for any  
purpose of the United States Government.

NAVAL TRAINING EQUIPMENT CENTER  
ORLANDO, FLORIDA 32813

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVTRAEQUIPCEN-IH-325	2. GOVT ACCESSION NO. AD-A095	3. RECIPIENT'S CATALOG NUMBER 206
4. TITLE (and Subtitle) Front-End Analysis: Generic and Nongeneric Models.		5. TYPE OF REPORT & PERIOD COVERED 9. Final Report, for Period June 1979 - August 1980.
		6. PERFORMING ORG. REPORT NUMBER NAVTRAEQUIPCEN IH-325
7. AUTHOR(s) B. E. Mulligan, Ph.D., and J. F. Funaro, CDR		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Training Equipment Center Orlando, Florida 32813		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NA
11. CONTROLLING OFFICE NAME AND ADDRESS Commanding Officer, Naval Training Equipment Center, Orlando, Florida 32813 //		12. REPORT DATE September 1980
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 45
		15. SECURITY CLASS. (of this report) Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Systems Analysis, Front-end Analysis, Training Analysis, Generic Information Commonality Analysis, Instructional System Development, Generic IS.)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  Front-end analysis is described as an iterative process by means of which the requirements of a system may be made progressively more definitive. The importance of information to the process - whether it is obtained through an empirical study or from a generic data base - is stressed. The degree of detail with which system requirements may be specified depends on the level of information available at the time they are formulated. As specificity of		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE  
S/N 0102-014-66011

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) 9 46

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

## 20. ABSTRACT

system requirements increase, there may be a corresponding advance in the state of the system. The analysis process may be degraded by time-cost constraints, etc., the primary result being a reduction in the amount and quality of information needed by the analyst to determine system requirements and alternative action plans at adequate levels of specificity. It is agreed that this degrading effect of constraints may be minimized by an information procurement and management system that would make available to the analyst generic data. A number of models for front-end analysis that take advantage of generic data bases are presented within the context of training systems. Each is evaluated in terms of the gain in specificity of training requirements and instructional regimens that it may achieve relative to nongeneric analyses carried out under constrained and constraint-free conditions.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

## TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
I	GENERAL OVERVIEW . . . . .	3
II	STRAIGHT-LINE FRONT-END ANALYSIS . . . . .	14
III	GENERIC INFORMATION IN FRONT-END ANALYSIS: TRAINING SYSTEMS . . . . .	23

[illegible]

# NAVTRAEQUIPCEN IH-325

## ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Decision Loop . . . . .	4
2	Front-end Analysis Loop for Large Organizations . . . . .	5
3	Flow Diagram of Front-End Analysis . . . . .	7
4	Levels of System Emergence . . . . .	8
5	Generic Information Management System . . . . .	9
6	Generic Model . . . . .	11
7	Generic Data-Based Front-End Analysis Loop . . . . .	12
8	Approaches to Analyses of Training Systems . . . . .	25
9	NAVAIR/NTEC ISD . . . . .	27
10	Specificity of Requirements: Training Program and Media . . . . .	29
11	Specificity of Requirements: Curriculum . . . . .	30
12	Levels of Specificity from Nongeneric Approaches . . . . .	32
13	Levels of Specificity from Approaches Based on Generic Tasks . . . . .	33
14	Levels of Specificity from Approaches Based on Generic Tasks and Objectives . . . . .	36
15	Levels of Specificity from Approaches Based on Complete Generic Data Base . . . . .	37
16	Components of Training Analyses Ranked According to Levels of Specificity Achieved . . . . .	38
17	New Technology Approach to Training Analysis . . . . .	39

## NAVTRAEQUIPCEN IH-325

### SECTION I

#### GENERAL OVERVIEW

Analysis is a natural human activity, a more or less logical form of problem-solving behavior. It occurs when the appropriate response to a problem is uncertain, i.e., when information is required to make a choice among alternatives. In contrast, a reflex is a non-analytical process. It is automatic and certain. No decision among alternatives is required. If your hand touched a red-hot surface, it would be withdrawn without equivocation. However, if your key broke in the lock of your car door, you would have a problem to which you might make many responses (some, perhaps, inappropriately reflexive).

The analytical character of our reasoning in problematic situations usually is not explicit. The various priorities, assumptions, and bits of information that underlie most of our decisions thus are not often open to evaluation. This intuitive approach serves us remarkably well except when (a) the cost or risk associated with decisions is high, and (b) the considerations on which decisions are based must be communicated effectively to others. These are precisely the conditions that have motivated efforts to objectify the analysis process. The following represents one attempt in this direction - an approach which stresses the central role of information in analysis.

At the core of analysis we find a fundamental process which may be conceptualized as a decision loop such as that in Figure 1. As the diagram shows, the existence of a problem creates a need for information. Once the needed information has been gathered, a decision is made among alternative courses of action directed at solution of the problem. When the decision is acted upon, a new problem emerges or the old problem may be redefined in greater detail. The cycle is then repeated at a finer level of specificity. Each repetition of the loop improves resolution of the problem and the action needed to solve it. This iterative process terminates when further analysis of the problem fails to yield any significant new information, or when further action is prohibited by constraints such as time and cost.

The elementary decision loop may be elaborated to encompass the activities that characterize the front-end analysis process in large scale system development projects. As indicated in the analysis loop illustrated in Figure 2, information assumes a role central to the whole process. The process itself is usually initiated by an operational requirement (OR) which arises in response to some anticipated or existing need in the fleet. The degree of detail specified in the OR reflects the level of information available at the time of its original formulation. Less information is initially available in the case of emerging systems than in the case of existing systems, and the early system requirements (which are developed from the OR) for emerging systems are correspondingly less detailed. Development of emerging systems thus presumes an increase in the specificity of system requirements based on an expansion of the supporting information.

Each cycle through the loop enlarges the information data bank and results in a further refinement of the system requirements. The system emerges as the requirements develop.



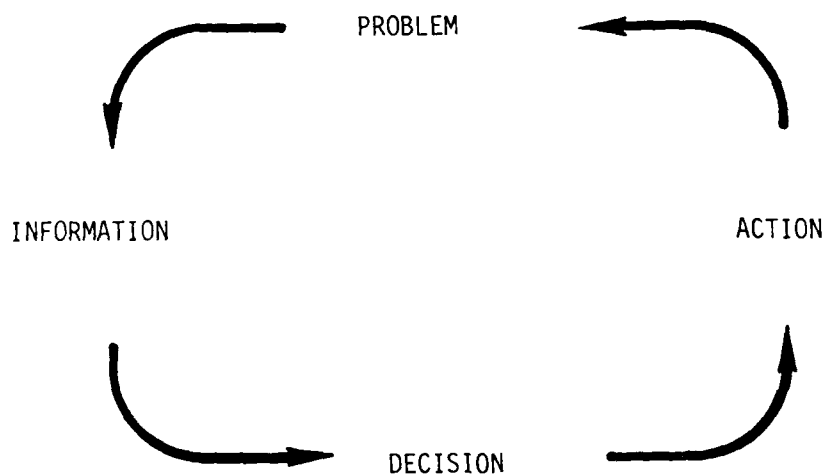


Figure 1. Decision Loop.

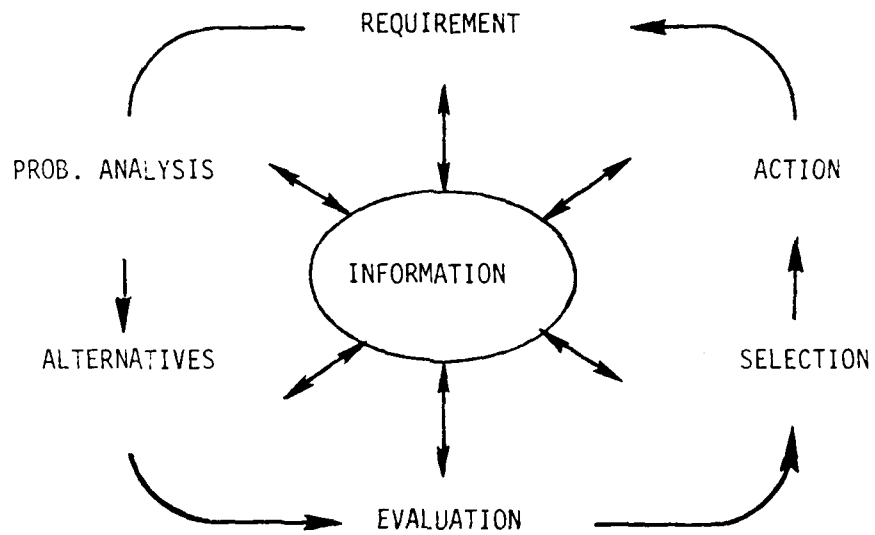


Figure 2. Front-End Analysis Loop for Large Scale System Development

At each level of refinement, decisions are made among alternative conceptualizations and action strategies. This requires information - both the information necessary for formulation of alternatives, and that necessary for evaluation and selection of the "best" from among them. The major source of this information is some form of problem analysis, a procedure for collecting and assimilating the data that characterize a system at its current level of development and provide the foundation for an advance of the system to its next level.

The alternatives generated by front-end analysis at one level (cycle) in the emergence of a system generally will not be the same as those generated in later cycles. As the data base of information builds up through repeated cycles around the loop, the alternative conceptualizations and strategies become progressively more functional and detailed, and the scenarios for action inherent in them become more realistic.

In addition to the system-specific data needed to identify alternatives, problem analysis also provides clarification of objectives and establishes an accurate picture of resources and constraints. It is in terms of these data that the various alternatives are evaluated. Given the required and available resources, and the constraints on further development, then it is possible to establish the projected costs, potential effectiveness, and likely risks entailed by each alternative. Essentially, it is this information that constitutes evaluation. And, like the information generated at the problem analysis stage of the loop, the evaluative information becomes more refined and specific on each successive cycle around the loop.

Output from the evaluation stage of front-end analysis provides the primary information base needed to select the optimal alternative. However, several additional kinds of information may also come into play during selection, e.g., past experience with similar alternatives; organizational policies, priorities, and long-range goals; technological state-of-the-art and capacity for innovative development; etc. These factors combine with resources and constraints data to form the criteria that are used to select the "best" from among the alternatives. The validity of the selection criteria improves as the information on which they are based increases, and so the alternative selected on each cycle through the loop approximates more and more closely an optimal plan for action.

The steps involved in this process may be illustrated in terms of a flow diagram such as the one in Figure 3. Note that, once the "best" alternative has been selected, a decision point is reached. If the specificity of the alternative is not adequate to proceed with an action (system development, design, etc.), a new system requirement is defined and analysis is repeated. This iterative approach to front-end analysis results in a step-wise increase in the specificity of system requirements and a corresponding advance in the state of the system, as illustrated in Figure 4.

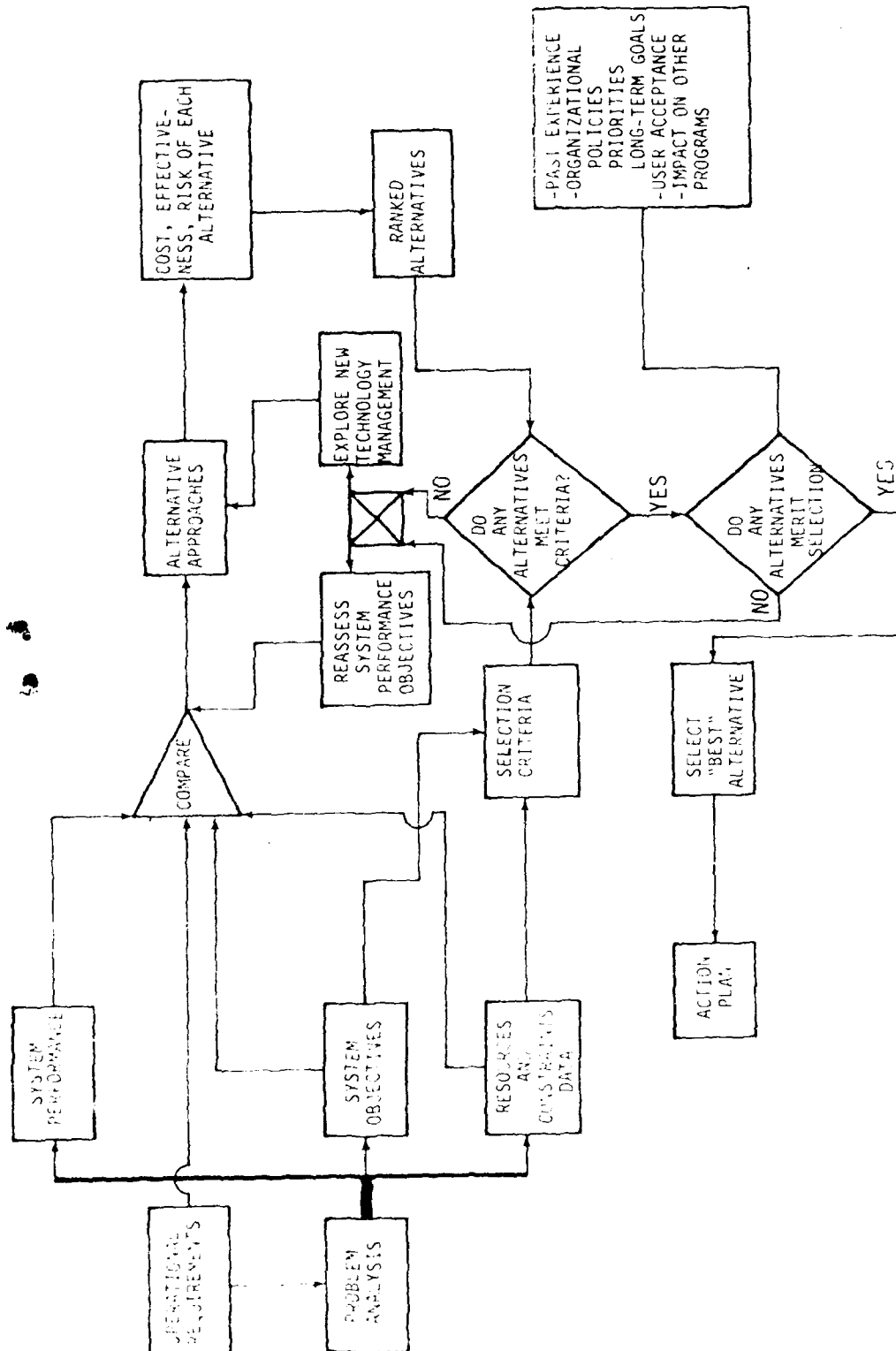


Figure 3. Flow Diagram of Front-End Analysis.

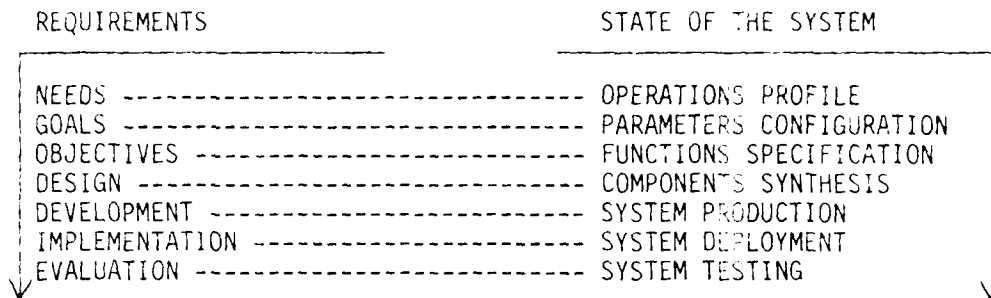


Figure 4. Levels of System Emergence.

System requirements formulated in terms of needs are less specific, based on less information, than those generated from goals statements. Likewise, if sufficient information is available to stipulate concrete objectives, the resulting system requirements will be more specific than if they were formulated in terms of more general goals statements. The point of this is that, as information regarding our needs, goals, and objectives increases, our view of what the system should accomplish becomes more definitive and sharply focused. The evolution of a system from a general profile of its desired operations to its ultimate deployment follows a parallel course of step-wise increments in specificity.

As knowledge of system requirements increases, the state of the system may be advanced. The alternatives generated at each level of analysis become more detailed, are based on more information, and permit a more definitive description of system parameters and functions. This is a straight-line evolution of an emerging system. It appears to be equally characteristic of conceptual, organizational, hardware, and training systems. It also applies to existing systems implemented at some less-than-ideal stage of development.

Can this straight-line process be short-circuited? If so, there would be a considerable savings in time and cost.

As we have seen, the key factor in the evolution of systems is information. Indeed, it might be argued that it is the procurement and management of information that constitutes one of the primary objectives of front-end analysis. The emphasis here is on the availability of information since this offers the most likely avenue for short-circuiting the long-term straight-line process of system development. Essentially, a method is needed for maximizing the utility of the information that is available at the time an operational requirement arises. This presupposes a system for categorizing, storing, and retrieving information - a system to which perhaps, each of the armed services could contribute, and from which each could draw the information it needed. Such a scheme is illustrated in Figure 5.

The generic information management system outlined in the diagram is not the usual "librarian's" model which takes in, files, and provides selective access to stored information. Instead, this categorical process is merely the

# NAVTRAEQUIPCEN IH-325

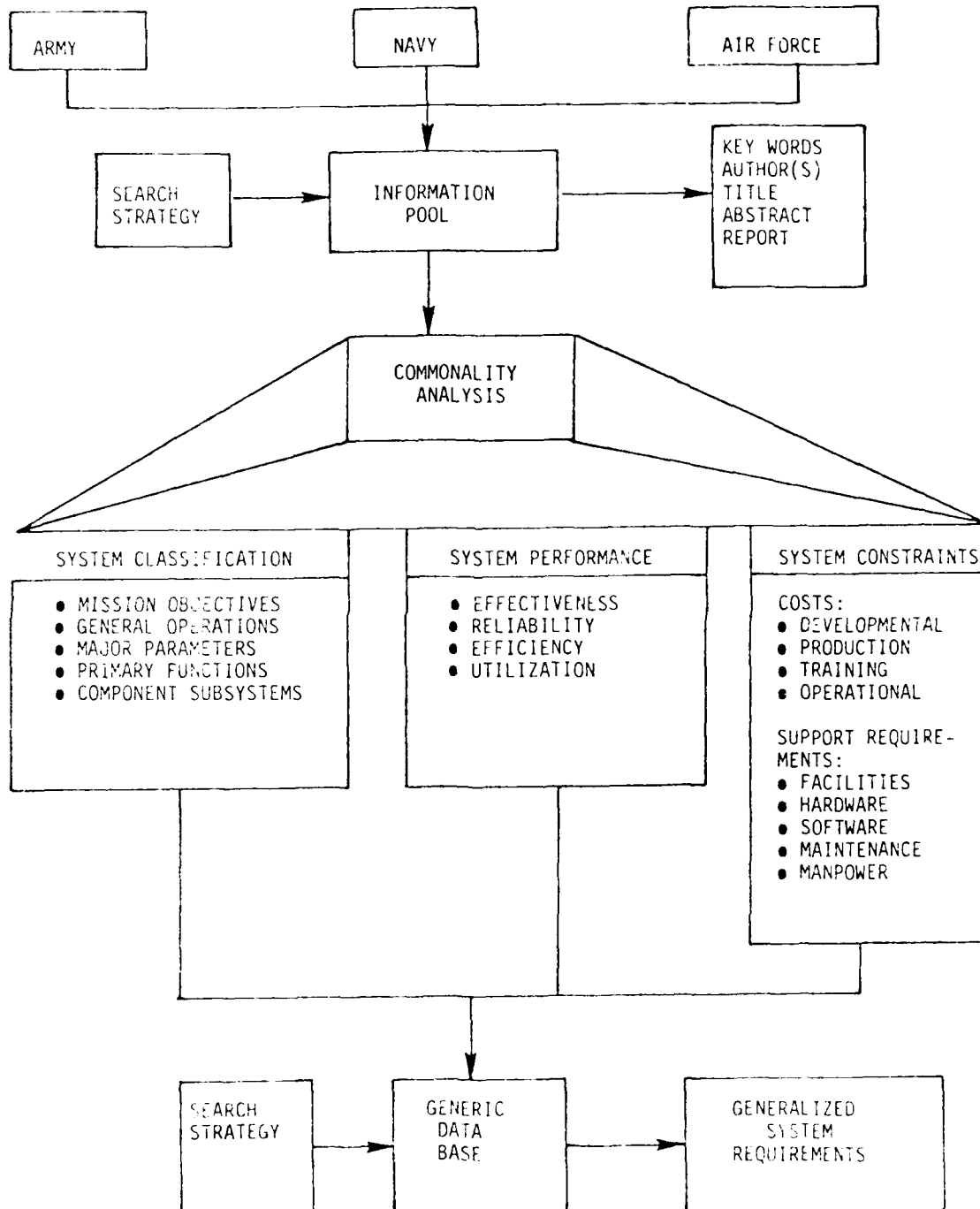


Figure 5. Generic Information Management System.

first important step in the generic model. The second step is a commonality analysis that is carried out on all systems of a given type that are available in the information pool. The purpose of a commonality analysis is, for any given type of system, to establish the generalized requirements that apply to all instances of that type of system. For example, we may have five different systems designed to achieve the same kinds of mission objectives. Obviously, these five systems - though different - must have some things in common. It may be that the general operations of these systems share certain key characteristics that are critical to mission accomplishment. It may turn out that certain major parameters are present in each system as well as a few primary functions. The main differences may be in the component subsystems that make up the hardware of each system. The overall picture which would emerge from this commonality analysis would tell us which system characteristics have been found to be essential, invariant, to the accomplishment of certain mission objectives, and which characteristics may be altered. When this data is combined with performance and constraint data, it is possible to evaluate both the invariant and variant system characteristics in terms of their real contributions to mission achievement.

Such commonality analyses produce generic data - data that is descriptive of system types rather than individual systems. This generic data would be stored (in addition to system-specific data) and made available for selective access in the model proposed here. In short, a generic data base would be established.

This process is illustrated in the diagram shown in Figure 6. Suppose a need arises for a new system and that time and/or resource constraints will not permit the straight-line evolution of the information base necessary to specify system requirements. The generic model offers a way around these constraints. The model says to go to the information pool and pull out existing data on systems that satisfy needs similar to the one we are now facing and then perform a commonality analysis. From the resulting generic data base, a set of generalized requirements can be determined that will serve as the "best estimate" of a system that will meet the new need. Furthermore, the generic data generated in the process can be stored and used in future system analyses. Even if future analyses are not constrained by either time or costs, the generic data base constitutes a superior information process, one which does not force us to either start from scratch, or work with a disorganized plethora of raw data, each time the need for a new approach to an old problem, or a unique approach to an entirely new problem, arises. In short, the generic model of information management permits us maximum utilization of existing information and thereby provides us with a more accelerated and less costly approach to the analysis of systems. In light of this, we can now alter our analysis loop to reflect this generic source of information as shown in Figure 7.

The thesis here is that the generic approach to information management has the potential of being our most viable tool for by-passing the long-term often expensive approach to front-end analysis. Our "looks" into the future are essentially estimates derived from information obtained in the past. There appears to be no way known to science or technology for getting around this.

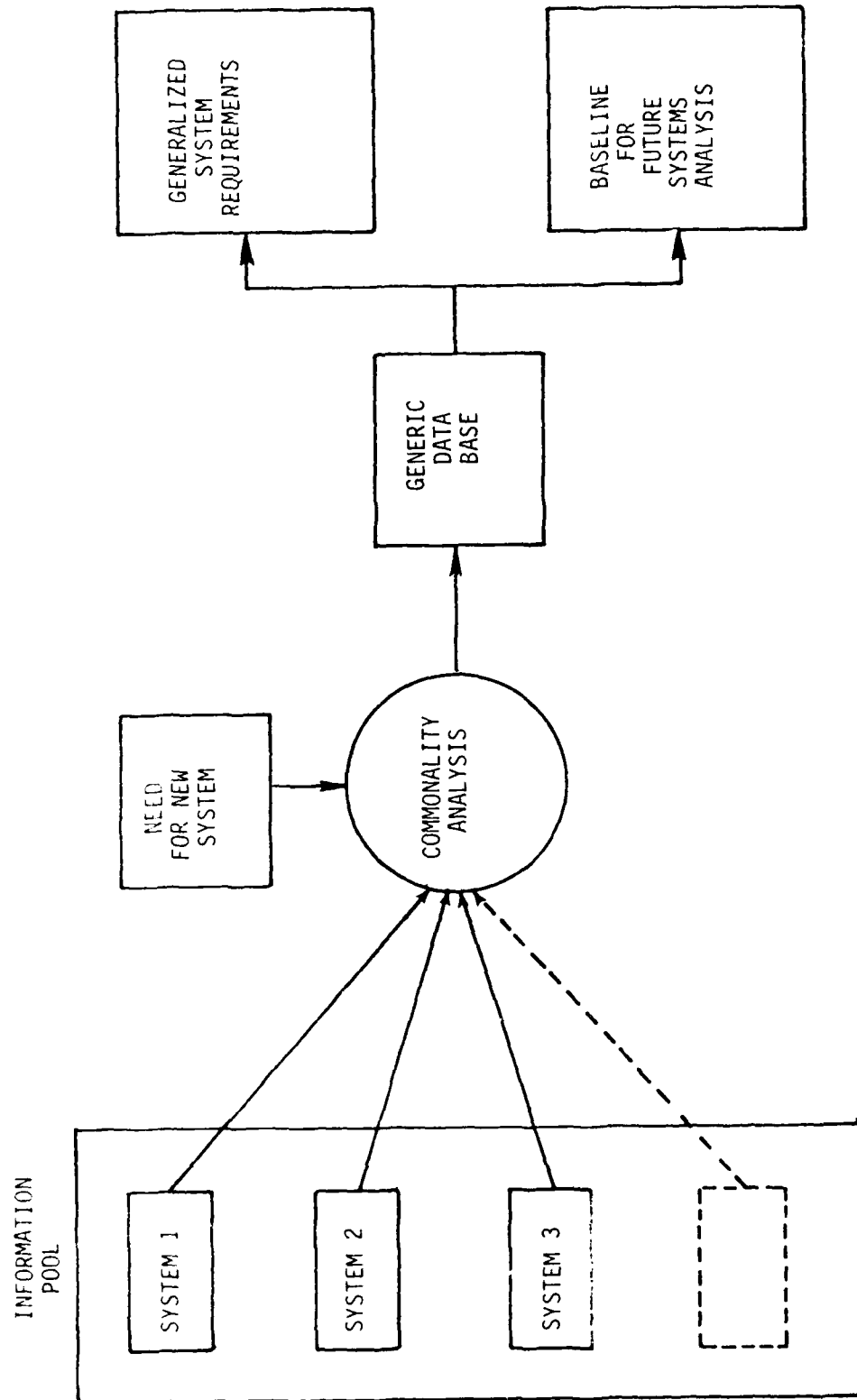


Figure 6. Generic Model.



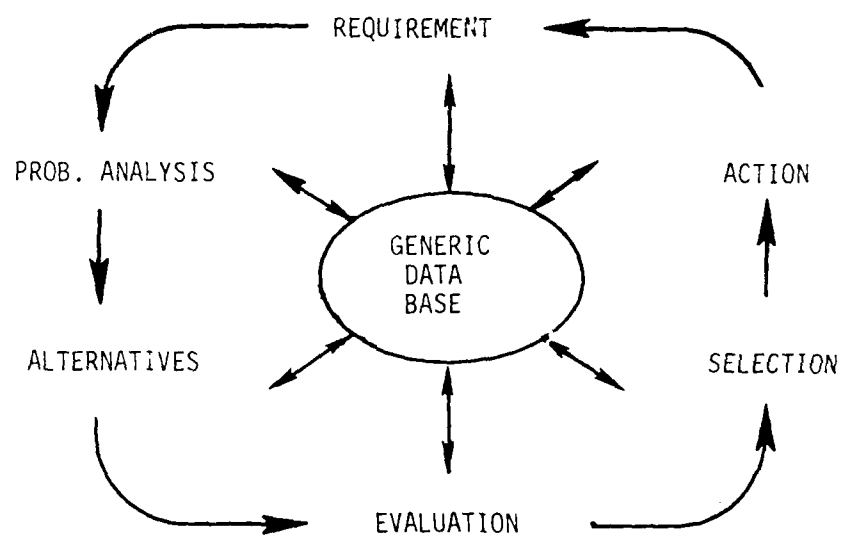


Figure 7. Generic Data-Based Front-End Analysis Loop.

NAVTRAEQUIPCEN IH-325

Since our best estimate of the future has to be gleaned from the past, we should proceed to establish a rational methodology which will optimize the usefulness of the information now available to us. Otherwise it will remain fragmented in isolated bits, will tend to be duplicated needlessly, and will not be generalized in application to future needs and systems.

## SECTION II

## STRAIGHT-LINE FRONT-END ANALYSIS

Any analysis is predicated upon the availability of information, whether it be qualitative or quantitative. However, the mere availability of information does not assure that any useful gain will be realized. In fact, the utilization of high density information in the solution of complex problems may be impeded by the absence of an appropriate strategy for analytically managing information. Ideally, such a strategy would provide a mechanism for integrating factual data, system objectives, management and budget priorities, and major sources of uncertainty. It would also identify decision points in the analytic process and indicate the nature of the information needed at each point.

The approach to front-end analysis described in this section is an attempt to make explicit the various steps, logic, and items of information currently regarded as being essential to evaluative and developmental planning at the Naval Training Equipment Center. The model to be described here is diagrammatically presented in Figure 3. Although costs and time constraints may require a more abbreviated analysis, i.e., the analysis must be short-circuited at some point in the process, an overall view of the entire process may aid in minimizing losses in analytic power due to inadvertent elimination of essential steps. Optimal strategies for short-circuiting the straight-line analysis process presented here will be described in the next section under the heading "Generic Information in Front-end Analysis: Training Systems".

The stimulus for a front-end analysis at the Naval Training Equipment Center can be an operational requirement (OR) generated by the Chief of Naval Operations (CNO). An OR may be produced in response to a problem within an existing fleet system or by the emergence of a new threat for which a counter capability must be developed.

The point of interest here is that the OR serves as the basis for justifying the funding necessary to carry out front-end analysis. Insofar as the analyst is concerned, the operational requirement stipulates the needs of the fleet and the time-cost limitations within which he must work. It is within this context that the analyst must frame the character of the process that ultimately will result in cost-effective alternatives from among which the "best" may be selected. It should be pointed out that the word "requirement", as used in the preceding section, is not synonymous with "operational requirement". System requirements, as opposed to the OR, refer to needs, goals, or objectives peculiar to the system called for by the OR. Successive iterations of front-end analysis as described in the first section of this report may be largely responsible for delineating and developing these requirements for emerging systems, and refining or re-defining these requirements for existing systems in need of additions, expansions, or revisions. As indicated in Figure 4, the specificity of system requirements increases as the state of the system advances. Consequently, the requirements for existing systems are usually available in a more detailed form than those for emerging systems. The significance of this for the analyst is that requirements specificity largely determines the degree of fineness with which alternatives may be specified and the accuracy with which

alternatives may be evaluated. Determination of system requirements is, therefore, of paramount importance to the analyst and this is most appropriately accomplished through a problem analysis.

Although time-cost constraints may prohibit a full-scale problem analysis such as that described by Funaro and Mulligan (1979)<sup>1</sup>, there are at least three categories of information that the analyst requires in order to successfully carry out a straight-line front-end analysis. These categories are (1) system requirements, (2) system performance, and (3) system resources and constraints. Documentation in each of these categories is normally contained in the problem analysis report. If such documentation is not available, and cannot be obtained due to constraints, the validity of the front-end analysis may be severely impaired. In such an instance, the analyst has little real data on which to base his evaluation other than the collective experience of those familiar with similar systems and his own educated speculations. This is one point at which the availability of a generic data base, as described in the next section, could contribute significantly to the validity of a front-end analysis. A similar problem may exist in the case of an evolving system for which system requirements, performance, resources, and constraints are only generally specified. It should be evident, therefore, that the starting point for a straight-line front-end analysis is the documentation contained in the problem analysis report.

Initially, as illustrated in Figure 3, the analyst is faced with a comparison of operational requirements, system objectives (or system requirements), and system performance. Several important questions arise as a result of this comparison. For example, are system objectives consistent with operational requirements? Laying aside the problem of operational requirements validity, which is a question the analyst should consider also, the answer to the foregoing question may be either "yes", "no", or "indeterminate". In case the answer is "yes", then the analyst has a strong indication that the system objectives at least specify the direction in which system performance should be aimed and resources concentrated. In case the answer is "no", then further analysis probably would not be productive until the reasons for the discrepancy have been discovered and the inconsistency resolved. In case the answer is "indeterminate", further explication of the OR probably would be necessary.

A second question inherent in the comparison is, are resources adequate to meet system objectives? Obviously, if the answer to this question is "no", the analyst is faced with a dilemma which must be resolved before proceeding further with the analysis. One option might be to scale down the system objectives to the limit permitted by the OR. A second option might involve the incorporation of new technological developments, more streamlined management systems, or more efficient utilization of existing manpower and physical resources. Similar reasoning would apply to the limitations that constraints exert on the realizability of system objectives.

---

<sup>1</sup>J. F. Funaro and B. E. Mulligan (July, 1979) "Problem Analysis and The Program Master Plan: Key Elements in the Instruction System Development Process", NAVTRAEQUIPCEN Report No. IH-314.

A third question that derives from the comparison, and perhaps the most interesting one in the case of existing systems, asks if system performance meets system objectives. Of course, this question would apply only to those areas of system performance for which objectives were available. However, if there are pertinent areas in which system performance has been documented, but for which there are no objectives, the analyst might well develop the needed objectives, making sure that they are consistent with the OR and that they will contribute to the evaluation of alternatives to be developed later in the analysis process. There are a number of areas of system performance that may, or may not, be pertinent to any particular system. Among the most frequently encountered areas of performance are those listed below.

1. Productivity: Output or output per manhour (e.g., student throughput).
2. Reliability: Average rate of failure (e.g., malfunctions) per operating period.
3. Maintainability: Number of manhours to perform repairs, system inspections, etc.
4. Validity: Correlation between system and post-system parameters (e.g., fidelity of simulation, transfer of training, entry versus output skill levels).
5. Safety: Number of accidents, hazards, etc.
6. Accuracy: Frequency of system errors.
7. Acceptance: Attitudes, morale, etc., of system personnel (e.g., management, instructors, etc.) and system users (e.g., trainees, product users in the fleet).
8. Ecological impacts: Energy conservation, environmental effects, public reactions, etc.
9. Effectiveness: Any of the above evaluated relative to system requirements, standards, specifications, etc.
10. Efficiency: Resources required (expended) to achieve system outputs such as manpower (e.g., student/instructor ratio), facilities, equipment, supplies (training "flights"/gallons fuel), and time (training objectives/unit instruction time).

The process of resolving questions raised by comparisons of system requirements, objectives, performance, resources, and constraints provides the analyst with an introduction to the creative and complex task of formulating alternative plans to meet the objectives of the system.

Alternatives provide decision makers with choices. The potential gain to be realized from the availability of choices, however, is clearly limited by the quality of alternatives from among which the choices are to be made, and the distinguishability of alternatives powerfully influences the certainty with which the decision maker may choose.

Quality and distinguishability of alternatives are thus two important goals towards which the analyst should strive. The achievability of these goals is largely dependent upon the adequacy of the problem analysis data since this is the most representative information on the state of the system available to the analyst. However, the analyst's experience, knowledge of similar systems, and analytic abilities are key ingredients in the formulation of viable alternatives. The analyst's willingness to consult with, and his openness to the opinions of, decision makers and experts in relevant fields are also contributing factors at this stage in front-end analysis.

There appears to be no known proceduralization of the creative activities involved in generating alternative action plans, any more than there are formulae for producing works of art. However, the analyst may find it useful to begin with the formulation of an "ideal" alternative plan. To do this the analyst pretends that he has limitless resources and no constraints. He is then free to ask himself, "Given the current state of technology, what are the characteristics of the system that would optimally satisfy system objectives?" A detailed listing of these characteristics provides the analyst, as well as the decision maker, with an upper limit on what can be achieved. The ideal may then serve as a kind of yardstick against which all other alternatives may be evaluated.

Once the ideal is obtained, constraints and resources may be fed into the picture and those characteristics of the ideal alternative that are affected may be determined. Constraints and alternatives may be added into the analysis in various ways, taking into account all possible trade-offs, and the result will be a number of alternative action plans that have been degraded from the ideal in various ways and to varying extents. For example, certain categories of system performance may be impacted little, if at all, by resource limitations, or cost and time constraints. Other performance categories may, however, prove highly sensitive to certain schedules for resource allocation, time phasing, or cost distribution. In any case, it is the analyst's responsibility to explore all feasible options in arriving at the alternative action plans that he will recommend to the decision maker.

Once the alternatives have been formulated, the next step in the analysis is to evaluate them. Essentially, this amounts to estimating the effectiveness, cost, and risk associated with each alternative. Usually, this step will have been performed in the process of generating the alternatives, but it is helpful to conceive of this activity as a separate step.

The effectiveness of a system amounts to a judgement about system performance. It presumes some yardstick against which performance may be evaluated. For example, if the reliability of a training device is such that the average rate of failure per operating period constitutes a 20% downtime, this would hardly be viewed as a reduction in effectiveness if required utilization time were only 40%, and if repairs constituted only routine adjustments or calibration by operating personnel. Should the downtime of the device interfere with program scheduling, however, even the 20% figure might be regarded as a reduction in system effectiveness. In this case, the requirement being impacted is one which stipulates student throughput capacity (production). If required student throughput can be achieved within the acceptable time frame only through

tight temporal coordination of all system components, then the 20% downtime of the training device may cause the productivity of the system to drop below required levels. Hence, in this instance, the requirement against which effectiveness is judged is productivity, i.e., output per time period. Even though no explicit requirement may have existed regarding training device reliability in this example, the contribution of reliability to system effectiveness could be determined from the more general production requirement.

The necessity for the analyst to indirectly derive criteria for effectiveness evaluations typically arises when the level of front-end analysis of a system becomes more detailed than the initial statement of the operational requirement and includes a fine breakdown of data into pertinent categories of system performance. As stated above, these categories include such items as productivity, reliability, maintainability, validity, safety, accuracy, acceptability, availability, security, and quality. Even if no specific requirements exist for some of these categories, if they represent important dimensions of system performance the analyst should develop some relationship between stated system requirements and relevant areas of performance, and, as in the example above, determine their contribution to system effectiveness.

A second important area for evaluation of alternatives is cost. The major categories in which cost analysis is carried out are developmental, procurement, and life-cycle cost. Developmental costs include analysis, design, research, program or prototype test and evaluation, and support. Life-cycle costs take into account recurring or continuing costs, nonrecurring costs (e.g., capital investments), and depreciation. Procurement costs usually consider only initial expenses such as facilities, hardware, implementation, spare parts, support, and reprourement.

At least three methods for carrying out cost analysis are in current use. They are the parametric method, engineering method, and analogous system method. Which of these methods the analyst chooses usually depends upon how well the controlling parameters of the system are understood, the degree of financial documentation available, and the time available to the analyst. Since the choice among, and application of, cost analysis methods is a complex subject beyond the scope of the present discussion, the reader is referred to an excellent summary treatment entitled "Economic Analysis Handbook" (Department of Defense, Defense Economic Analysis Council, second edition).

Obviously, alternatives cannot be meaningfully compared if their associated costs have not been determined in a manner that is both accurate and consistent across all alternatives. Furthermore, effectiveness of alternatives cannot be accepted as a basis for selecting among alternatives if it is not known what it will cost to achieve the effectiveness promised by each. If cost and effectiveness have been quantified for each alternative in a manner that is standard across all, then it is possible to develop a cost-effectiveness index for each alternative. While this relative quantity may be valuable in evaluating alternatives, it should be reported together with the absolute values of cost and effectiveness for each. The relative values of two alternatives may be the same, but the absolute effectiveness of one may be considerably greater than that of the other even though the absolute difference in costs of the two may be insignificant. Whatever the cost analysis technique is that the analyst adopts,

care should be taken to document all figures and the assumptions underlying cost projections and computations. This is especially important in establishing the appropriate time basis for comparison of costs for alternatives. For example, one alternative action plan may require two years of developmental costs to obtain a five year benefit period whereas a second alternative may require just one year of developmental costs, but provide only three years of benefit.

The third major datum needed for the evaluation of alternatives is risk. At this stage in the analysis process risk estimation is mainly based in the subjective judgement of the analyst. Based on his knowledge of the uncertainties that underlie each alternative, the tentativeness of the assumptions on which the alternative formulations were founded, the likelihood that what was assumed can in fact be realized, the analyst might develop some sort of rating scale by means of which his subjective uncertainty could be assigned a numerical risk value. These values should be accompanied by an enumeration of the uncertainties that led to them. Risk values serve to inform the decision maker of the analyst's best guess regarding the probability that a plan of action, as proposed, will succeed, i.e., the probability that the conditions assumed for a given action plan will be met. Together, estimates of effectiveness, cost, and risk provide a necessary (if not sufficient) basis for determining the relative desirability of the various alternative action plans under consideration. Based on these estimates the alternatives may be ranked from "best" to "worst".

It was suggested above that a constraint-free "ideal" alternative be determined. Of course, the ideal would be placed in the top position of the ranking of alternatives. Although this ranking merely represents ordinal relationships among the alternatives, some interesting insights may be gained by trying to estimate the distances between alternatives on the ordinal scale, i.e., how much better is each alternative as compared with the one ranked just below it? For example, it may be discovered that relative distance between the ideal and the highest-ranked realizable alternative is not appreciable. If such were the case, this would indicate that this realizable alternative is about as good a solution to the problem as could be achieved even without any constraints. Of course, such a result may mean that either the best realizable alternative is not worth the expenditure of resources required to effect it, or that the expenditures to achieve this alternative can be expected to yield highly desirable results. Similar reasoning would apply to alternatives placed at lower positions in the ranking.

Another way of providing the decision maker an estimate of the distance between alternatives is to use the most similar system already deployed as a benchmark. For example, when presenting training system alternatives for a new fighter aircraft the analyst could include the existing training systems for the current fighter. The cost, effectiveness, and risks of the deployed system are known with a high degree of certainty. Comparing the parameters of each alternative to the baseline system permits statements such as twice as effective, equal in efficiency, etc., which provide a better insertion feed to a decision maker thoroughly familiar with the existing systems. Ranking also helps to identify the relative contributions of the many factors that determine differences in effectiveness, cost, and risk. For example, a particular alternative may be ranked below another even though the two may be equal in all important areas of performance if the cost associated with one greatly exceeds



that of the other. Such cost differences may reveal fundamental differences in the efficiency of one or more system components. Perhaps the hardware, for example, designated for two alternatives differs significantly in development and operating costs even though both are equally effective. The alternative incorporating the more expensive hardware would be ranked in the lower position even though it might be more desirable for other reasons, e.g., philosophical, aesthetic, political, or personal. In any case, the ranking of alternatives provides the decision maker with an explicit and objective summarization of the trade-offs inherent in the alternative action plans from among which a choice must be made.

There is a further benefit which the ranking of alternatives provides. The formulation of alternatives inevitably involves assumptions that the analyst must make in order to bridge areas of uncertainty. At this point, the analyst has already attempted to make explicit these uncertainties through the assignment of risk values to each of the alternatives and they, in turn, have influenced the ranking. As a means of further evaluating the magnitude of influence of these uncertainties, the analyst may alter the assumptions made for major parameters of the system, calculate the effects of these changes on effectiveness and cost, and finally determine how these changes are manifest in the ranking of alternatives. If the ranking is sensitive to changes in basic assumptions, both the direction and magnitude of influence of uncertain parameters may be determined. In case an area of uncertainty is associated with a high risk value, the new ranking of alternatives may provide a basis for selecting a more safe plan of action. Conversely, if the ranking proves insensitive to this sort of analysis, then it is probably safe to assume that the uncertainties encountered in the formulation of alternatives will not invalidate the relative desirability of alternatives reflected in the original ranking. Such evaluations of the influence of uncertainty on decision-making have proved valuable in economic analysis. Three methods that are commonly used are contingency analysis, sensitivity analysis, and "a fortiori" analysis (see the Economic Analysis Handbook).

At some point in the analysis prior to beginning the selection process, it is the task of the analyst to develop selection criteria. These criteria comprise a list of statements, preferably quantitative, that delineate in detail the maximum acceptable limits permitted by constraints and resources, and the minimum acceptable limits afforded by system objectives, standards, and specifications. Under the heading "Constraints and Resources", the analyst should specify such items as the maximum acceptable time frames for completion for each phase of the system, the upper limits on funding levels available for each phase and component of the system, the facilities and other physical resources that will be available at each stage, and the characteristics of the manpower, management, and organizational structure that will be available during each phase of system emergence. Under the heading "System Objectives, Standards, and Specifications", the analyst should include such items as the minimal values acceptable within each major area of system performance and for each phase of system emergence (analysis, design, development, testing, production, and implementation). Since these are objective statements of maxima and minima that have already been determined to be consistent with operational requirements, overall funding levels, time constraints, etc., the analyst should regard them as inflexible boundaries that define the region of acceptance for all alternatives.

Since it is likely that, in most cases, the analyst would have formulated alternatives with these boundaries in mind, no fully developed alternative (other than the ideal) ordinarily would be rejected by the selection criteria. Such criteria are valuable because they explicitly delineate the arena of possible actions. The analyst may, however, recommend to the decision maker that some changes in criteria are needed.

The first step in the selection process merely involves checking each alternative against the selection criteria. This step is illustrated in Figure 3 by the question "Do any alternatives meet criteria?" If the answer to this question is "no", then the analyst is faced with either a reassessment of system objectives and performance specifications, or exploration of new technological developments and management-organizational structures. The information gained in the first cycle through the front-end analysis loop may, indeed, provide a basis for a revision in system objectives and performance expectations. If so, a new set of alternatives is generated, evaluated, and ranked. If not, perhaps new technological developments will provide more cost-effective approaches to system development. Or, perhaps, the utilization of automated information handling will permit a more efficient use of available manpower and a more streamlined management hierarchy. These possibilities, if feasible, would also lead to the formulation of a new set of alternative action plans.

Alternatives that are found to meet the selection criteria should undergo a still further form of evaluation prior to final selection. This stage of evaluation is characterized by the question in Figure 3 "Do any alternatives merit selection?" Obviously, this stage in the evaluation process is more subjective than that involving selection criteria. It is at this point that the decision maker (as well as others such as system users, outside experts, etc.) should become involved in selection among those alternatives that satisfy basic criteria. Given the collective knowledge and past experience of all concerned, some alternative may be viewed in a more desirable light than others for a host of reasons that are largely intuitive and which may reflect intangible benefits not previously considered. Also, organizational policies, priorities, and long-term goals may favor one alternative over another. Other factors to be considered are user acceptance and the impact on other programs of any alternative that is selected. It is possible that, at this point in the selection process, none of the alternatives may be judged to merit selection. Should this occur, the analyst must return to the drawing board and cycle back through the analysis loop just as he did when none of the alternatives were found to meet selection criteria.

Assuming that one or more alternative is found to merit selection, the final stage of the process has been attained. Selection of the "best" from among those alternatives judged to merit final consideration is, perhaps, the least objective stage of the process. Not only is the diversity of individuals and organizations involved in the process greater at this stage, but the influence of non-system forces (international events, national politics, state of the economy, etc.) is more likely to be manifest. The greater the magnitude of the system under consideration, the more likely that these sources of influence will impact the decisions that are made during the final selection stage of front-end analysis. Assuming a "best" alternative is selected, the ground work then has been laid for a full-scale development of the action plan.

NAVTRAEQUIPCEN 1H-325

At this point, the straight-line approach to front-end analysis has been completed.

## SECTION III

## GENERIC INFORMATION IN FRONT-END ANALYSIS: TRAINING SYSTEMS

In the introductory section of this report, front-end analysis was described as an iterative process by means of which the requirements of a system may be made progressively more definitive and brought more sharply into focus. The importance of information to the analysis process was stressed and the point was made that the degree of detail specified in a system requirement reflects the level of information that is available at the time of its formulation, i.e., as information regarding the needs, goals, and objectives of a system increases, our view of what the system should accomplish becomes more specific. And, as the specificity of system requirements increases, there may be a corresponding advance in the state of the system, as shown in Figure 4. The alternatives generated at each level of analysis become more detailed, are based on more information, and permit a more definitive description of system parameters and functions. This progressive, step-wise, development of information and system requirements was referred to as the straight-line approach to front-end analysis, as described in Section II of this report.

Analyses, as they are carried out in the real world of complex systems and unavoidable constraints, usually must depart from the straight-line process. If time-cost constraints impose a less-than-optimal approach to analysis, the result is nearly always a reduction in the amount and quality of information needed by the analyst to determine system requirements and alternative action plans at an adequate level of specificity. Often, the approach taken by the analyst working under prohibitive constraints amounts to little more than rule-of-thumb or educated guess-work. It is, thus, of paramount importance to provide the analyst with rational strategies that may be adopted in the event that the long-term straight-line approach to front-end analysis is precluded by constraints. It appears that the most likely avenue for short-circuiting the straight-line process would be an information procurement and management system, one that would maximize the availability and utility of information that is needed at the time a system requirement arises. A generic information system, such as that suggested in Section I of this report, seems to offer the essential elements for developing alternative approaches to front-end analysis. It is the purpose of this section to explore some of these approaches within the context of training systems.

As is the case for any system, front-end analysis of training systems is conducted in order to specify training requirements, establish instructional alternatives, cost analyze each alternative, evaluate the effectiveness of each alternative, and finally to select the most cost-effective plan of action. Although the rigor of the approach to front-end analysis of training systems may vary depending on the severity of the constraints encountered, the basic steps of the analysis process remain unchanged. Essentially, this means that the principal effect of constraints on front-end analysis is to reduce the rigor with which it can be carried out and thereby diminish the level of specificity at which instructional regimens can be delineated. This, in turn, may degrade the validity of the alternative that is selected as the most cost-effective solution to the training problem.

The level of specificity required for instructional regimens depends upon the degree of detail that is needed to decide among alternatives. For example, if the problem is to decide whether the training effectiveness of an existing program will benefit from a curriculum revision, the extensiveness of the analysis would be limited to identification of any areas of weakness in the existing curriculum and providing cost-effective alternatives. In this case, the decision to revise hinges on the cost of developing and implementing each alternative curriculum relative to the gain in training effectiveness expected for each. By contrast, the degree of detail needed to generate the lesson specifications and appropriate media selections for alternative curricula designs would be considerably greater. Even if the constraints on front-end analysis in this situation would not prohibit an in-depth examination of curricula alternatives, such an approach would be deemed inappropriate since it would exceed the level of specificity required to make the needed decision. The above example pinpoints a question which must be addressed at the outset of any front-end analysis, viz., is the level of specificity that is required to establish alternative instructional regimens "greater than", "less than", or "equal to" that which is achievable given the existing constraints?

If the answer to the above question is either "less than", or "equal to", then the analyst is free to select an approach that will be just sufficiently rigorous to render the level of detail necessary to formulate adequately specific training requirements and instructional regimens. Essentially, in this case, the analysis is constraint free. On the other hand, if the answer to the above question is "greater than", then the analyst is limited to an approach which will be less rigorous than that necessary to render sufficiently specific instructional alternatives. In this case, the analyst must select an approach that will be achievable rather than one tailored to the nature of the training problem. It is with this class of less-than-ideal approaches to front-end analysis of training systems that this section is primarily concerned. The trade-off between constraints and achievable specificity of requirements, and the ultimate effect of this trade-off on the levels of instructional regimens that may be achieved, is illustrated in Figure 8. Note that, if the achievable level of specificity is not less than that which is needed, an optimal approach to the development of instructional regimens may be taken. If such is not possible, and if there are no means by which the analyst can minimize the prohibitive influence of constraints, the result is a degraded approach to analysis which yields a more grossly specified instructional product. It is unfortunate that, often, the analyst has only these two choices available. As illustrated in Figure 8, the availability of generic information may provide the analyst with an approach that may be far greater in its capacity to specify levels of instructional regimens. An analogous possibility also exists in the case of an approach which capitalizes upon new media technology.

Before examining the less-than-ideal approaches to training analysis, it will be instructive to consider the steps that would be taken in a relatively constraint-free situation, keeping in mind that any of these approaches may be distinguished by the steps that are taken in order to obtain the data for

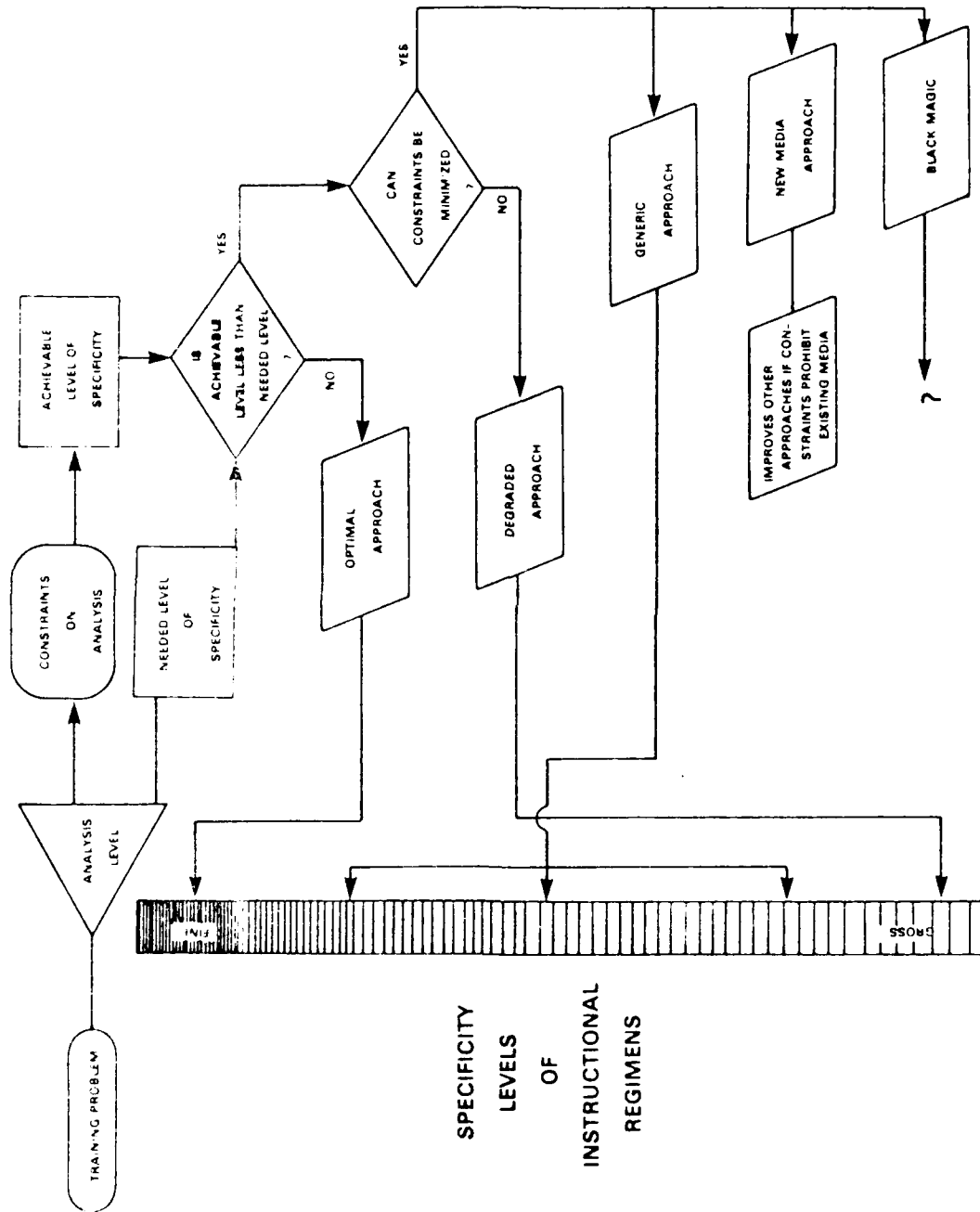


Figure 8. Approaches to Analyses of Training Systems.

training requirements formulation. For this purpose, the NAVAIR/NTEC ISD model (Funaro and Mulligan, 1978<sup>2</sup>; Mulligan and Funaro, 1979<sup>3</sup>) will be regarded as a kind of pragmatic ideal the successive stages of which may be used as a basis for comparison with those of more constraint-laden approaches. The major phases and tasks of this model are diagrammed in Figure 9. Only the initial phase of ISD is designated as analysis, the remaining phases being design, development, implementation, and quality control. However, it should be clear that a straight-line front-end analysis (which works on the outputs of the problem analysis shown as the first task in Figure 9) must, at least conceptually, extend as far into the successive phases of the ISD process as necessary in order to arrive at reasonable estimates of training requirements and time-cost constraints. Usually, training requirements will have been determined at a proper level of specificity by the end of the design phase of ISD. However, estimation of physical and manpower resources, time frames, and cost must take into account all ISD phases from analysis to implementation and quality control. Essentially, then, the NAVAIR/NTEC ISD model represents an optimum alternative for satisfying a training problem. If time, funds, and resources permit a full-scale ISD, it would appear that this would always be the analyst's recommended first choice. While this is generally true, in the area of training there is one important exception.

The exception is a generalized training system. In this case the system is supposed to prepare students in the concepts and tasks that are prerequisites for further specialized training, where all of the specialized programs require a common background of entry-level skills. The generic nature of this background is predicated upon the commonality that exists among the different areas of specialty. Assuming that each of the specialized training programs had been developed through ISD, and that a commonality analysis such as that illustrated in Figure 5 had been carried out on the task listings, behavioral objectives, and training media (including training support resources) generated during each of the individual ISDs, this would constitute a generic data base from which the training requirements for the generalized system could be determined. Not only would no further ISD be necessary, but the generalized data base itself would specify the requirements for the generalized system. In fact, the generic data base would constitute the most appropriate picture of the training that would be needed to optimally prepare students for entry into the more specialized programs. The generalized requirements obtained from the generic data base serve as the "best estimate" of a system that will meet the needs of generalized training. Furthermore, as illustrated in Figure 6, generic data may serve as a base line for future system analyses, especially those that are limited by constraints.

---

<sup>2</sup>Funaro, J. F. and Mulligan, B. E. (July, 1978), "Instructional Systems Design: The NAVAIR/NAVTRAEQUIPCEN Model", NAVTRAEQUIPCEN Report No. IH-304.

<sup>3</sup>Mulligan, B. E. and Funaro, J. F. (February, 1979), "Issues in the ISD Process: The NAVAIR/NAVTRAEQUIPCEN Model", NAVTRAEQUIPCEN Report No. IH-309.

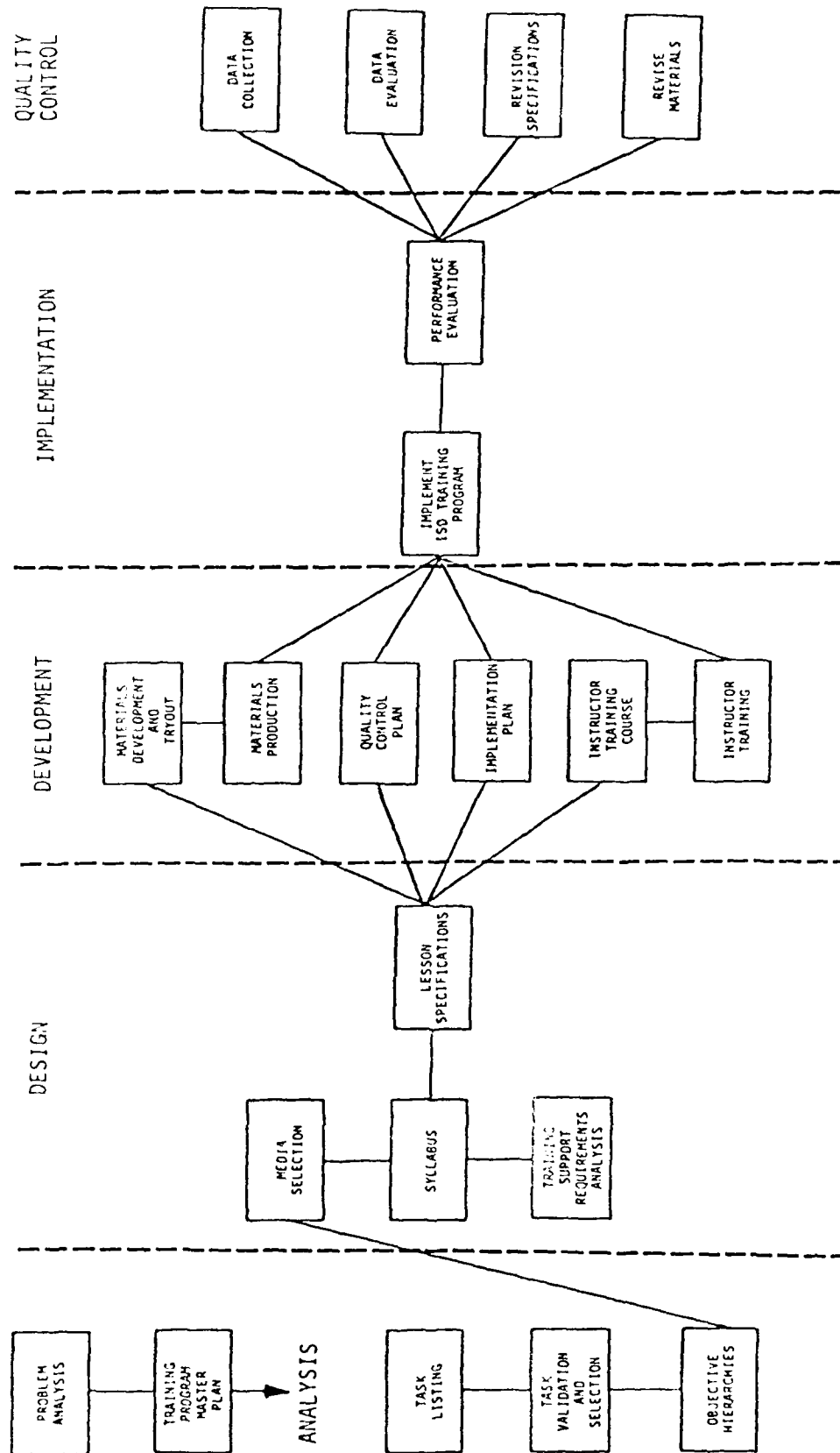


Figure 9. NAVAIR/NTEC ISD.



Since the relative merits of the various generic approaches to training analysis that will be considered are determined by the specificity of requirements each provides, it may be useful to consider the matter of specificity in somewhat concrete terms before proceeding further. As indicated in Figures 10 and 11, the specificity of requirements is determined by the level of analysis that is carried out. Three categories of requirements are especially important in the area of training, viz., training program requirements, instructional media requirements, and instructional curriculum requirements. If the analysis is not carried out beyond the program level, requirements can be stated only in the most general of terms, containing none of the detailed information necessary for instructional system development. Specification of training program requirements is limited to identification of general performance areas only, and media requirements may be designated only in terms of general media classes. Curricula cannot be developed beyond general instructional content areas, and the overall structure of the curriculum can be phased and sequenced only in terms of broadly defined instructional blocks. By contrast, if a task analysis of the training program has been completed, the result is a marked increase in the specificity of all requirements. As shown in Figures 10 and 11, if the analysis is extended beyond task to behavioral objectives, the specificity of requirements in all categories attains a level of detail that is optimal. It is this level of specificity which is obtained from a full-scale ISD. It is when constraints will not permit a level of analysis through the determination of behavioral objectives that the availability of a generic data base could contribute significantly to the determination of more finely delineated requirements than would otherwise be achievable. For example, if the operational requirement calls for the development of a training device, and if the analyst has available to him only data at the task level, he may specify requirements for types of displays and manipulanda, etc., for the device, but he will not have sufficient information to stipulate with any degree of accuracy such characteristics of the device as fidelity of simulation of display, response, and environmental dimensions (modality, dynamic-static, color, etc.; manipulanda characteristics, response feedback, motion cues, etc.). However, if the system under consideration were one of a number of similar systems with common characteristics, generic information derived from previous analyses of these systems could be used to enhance the level of detail at which the requirements for the device under consideration could be specified. In this case, the augmentation of task level requirements with generic requirements would not yield a level of specificity equivalent to that obtainable through a full-scale ISD, but it would yield a level of specification greater than that achievable on the basis of task level information alone.

In the area of training the alternative action plans to be determined by the analyst are instructional regimens, i.e., descriptions of training programs including task, behavioral, media, and curricula requirements (as well as support, time, funding, etc. requirements). It is, therefore, meaningful to compare the various approaches to training analysis on a continuum of specificity of instructional regimens that may be achieved by each approach. As pointed out earlier, the various approaches to training analysis may be distinguished on the basis of the steps that constitute each. Insofar as front-end analysis of training is concerned, however, the various approaches may be adequately distinguished in terms of three stages - the program level, the task analysis level,

LEVEL OF ANALYSIS		SPECIFICITY OF TRAINING REQUIREMENTS	SPECIFICITY OF MEDIA REQUIREMENTS
PRO-GRAM	TASKS	<ul style="list-style-type: none"> <li>• GENERAL PERFORMANCE AREAS</li> </ul>	<ul style="list-style-type: none"> <li>• GENERAL MEDIA CLASSES</li> </ul>
		<ul style="list-style-type: none"> <li>• SPECIFIC PERFORMANCE AREAS</li> <li>• TYPES OF TRAINING AND PROFICIENCIES FOR EACH PERFORMANCE AREA</li> </ul>	<ul style="list-style-type: none"> <li>• MEDIA CHARACTERISTICS FOR EACH PERFORMANCE AREA</li> <li>• ACCURACY OF PERFORMANCE MEASUREMENT REQUIRED OF EACH MEDIUM</li> <li>• TYPES OF DISPLAYS AND MANIPULANDA REQUIRED OF HANDS-ON MEDIA</li> </ul>
	BEHAVIORS	<ul style="list-style-type: none"> <li>• INDIVIDUAL BEHAVIORAL UNITS</li> <li>• PROFICIENCY LEVELS AND SEQUENCES OF BEHAVIORS IN INSTRUCTIONAL UNITS</li> <li>• MINIMUM INFORMATION AND LOGIC REQUIREMENTS FOR COGNITIVE AND MNEMONIC BEHAVIORAL UNITS</li> <li>• MINIMUM STIMULUS AND RESPONSE CHARACTERISTICS REQUIRED FOR PERCEPTUAL-MOTOR BEHAVIORAL UNITS</li> </ul>	<ul style="list-style-type: none"> <li>• MEDIA CHARACTERISTICS FOR EACH BEHAVIORAL UNIT</li> <li>• ACCURACY OF PERFORMANCE MEASUREMENT REQUIRED OF EACH MEDIUM</li> <li>• INFORMATIONAL DIMENSIONALS (STORAGE AND PROCESSING CAPACITY, RATE AND ORDER OF PRESENTATION, ETC.) REQUIRED OF EACH MEDIUM</li> <li>• FIDELITY OF SIMULATION OF DISPLAY, RESPONSE, AND ENVIRONMENTAL DIMENSIONS (MODALITY, DYNAMIC-STATIC, COLOR, ETC.) MANIPULANDA CHARACTERISTICS, RESPONSE FEEDBACK, MOTION CUES, ETC.) REQUIRED OF EACH MEDIUM</li> </ul>

Figure 10. Specificity of Requirements: Training Program and Media

SPECIFICITY OF CURRICULUM REQUIREMENTS		
LEVEL OF ANALYSIS	PROGRAM	<ul style="list-style-type: none"> <li>• GENERAL INSTRUCTIONAL CONTENT AREAS</li> <li>• COURSE DURATION, SEQUENCES OF INSTRUCTIONAL UNITS, TIME DEVOTED TO ACADEMIC, TRAINER, AND OPERATIONAL INSTRUCTION DETERMINED BY FACTORS EXTERNAL TO TRAINING REQUIREMENTS</li> </ul>
	TASKS	<ul style="list-style-type: none"> <li>• INSTRUCTIONAL CONTENTS AND LEVEL OF TRAINING FOR EACH PERFORMANCE AREA</li> <li>• COURSE DURATION AND MIX OF ACADEMIC, TRAINER, AND OPERATIONAL INSTRUCTION DERIVED FROM SUBDIVISIONS OF KNOWN TASK PERFORMANCE AREAS AND FACTORS EXTERNAL TO TRAINING REQUIREMENTS</li> <li>• SEQUENCES OF INSTRUCTIONAL UNITS BASED ON HIERARCHY OF TASK SUBDIVISIONS</li> </ul>
	BEHAVIORS	<ul style="list-style-type: none"> <li>• INSTRUCTIONAL CONTENTS AND LEVEL OF TRAINING FOR EACH BEHAVIORAL UNIT</li> <li>• INFORMATIONAL AND LOGIC CHARACTERISTICS OF INSTRUCTIONAL CONTENTS FOR COGNITIVE AND MEMORIC BEHAVIORAL UNITS</li> <li>• COURSE DURATION AND MIX OF ACADEMIC, TRAINER, AND OPERATIONAL INSTRUCTION DETERMINED BY HIERARCHY OF BEHAVIORAL OBJECTIVES, PRINCIPLES OF MOTIVATION, AND FACTORS EXTERNAL TO TRAINING REQUIREMENTS</li> <li>• SEQUENCES OF INSTRUCTIONAL UNITS DERIVED FROM HIERARCHY OF BEHAVIORAL OBJECTIVES</li> </ul>

Figure 11. Specificity of Requirements: Curriculum.

and the behavioral analysis level. This is illustrated in Figure 12 for three nongeneric approaches to training analysis. There it can be seen that if constraints permit task analysis and behavioral analysis, the analyst may complete the remaining front-end steps in the ISD model and define alternative instructional regimens at a high level of specificity. By contrast, if constraints will not permit task analysis, training requirements must be estimated from statements of program goals, objectives, etc., and the analyst is limited to determinations of general classes of media and instructional content areas. Consequently, the alternative instructional regimens that can be formulated on the basis of such limited information are necessarily of gross specificity. As the information available to the analyst increases, so too does the specificity of the training, media, and curricula requirements. As shown in Figure 12, if constraints will permit just a task analysis, an intermediate level of specificity may be achieved for instructional regimens. In these three instances no generic information is assumed to be available to the analyst, a condition that typifies most training analyses.

It should be clear that the likely validity of any instructional regimen, or plan, will be greatest if the information is available to permit a high degree of specificity in its formulation. The question of importance at this point is what magnitude of gain in specificity of instructional regimens can be expected if various degrees of generic information can be incorporated into the training analysis? Consider first the gain that may be obtained by the inclusion of a generic task listing in the analysis process, as illustrated in Figure 13.

The tornado-like funnel in the upper right hand corner of Figure 13 is meant to symbolize the collection of a number of task listings drawn from systems whose key parameters have sufficient commonality to permit the derivation of a generic task list, or data base (a suggestion of how such a data base might be organized is presented in Figure 5). For purposes of comparison, two nongeneric approaches are included on the diagram in Figure 13. They are shown on the left side of the diagram for the case where a "yes" answer is given to the question, will constraints permit full task analysis? The left-most vertically descending sequence of steps is, as in Figure 12, a full-scale ISD analysis. The approach that results if a "no" answer is given to the question, will constraints permit behavioral analysis?, is limited solely to a task listing from which training and other requirements must be determined and instructional regimens formulated. As the diagram indicates, the level of specificity that can be achieved in the latter case is significantly reduced from that attainable with a full ISD.

The gain in number of approaches to analysis due to the availability of the generic task data base occurs on the "no" side of the initial question, will constraints permit full task analysis? As was shown in Figure 12, the lack of a generic task data base at this point limits the analysis to the program level which results in a very gross degree of specification of instructional regimens. Hence, the advantage of having a generic task data base is realized when constraints will not permit full task analysis. As the diagram in Figure 13 indicates, however, there is one approach which results from the availability of a generic task data base that is superior even to that obtained when constraints do permit a full task analysis.

## NON GENERIC APPROACHES

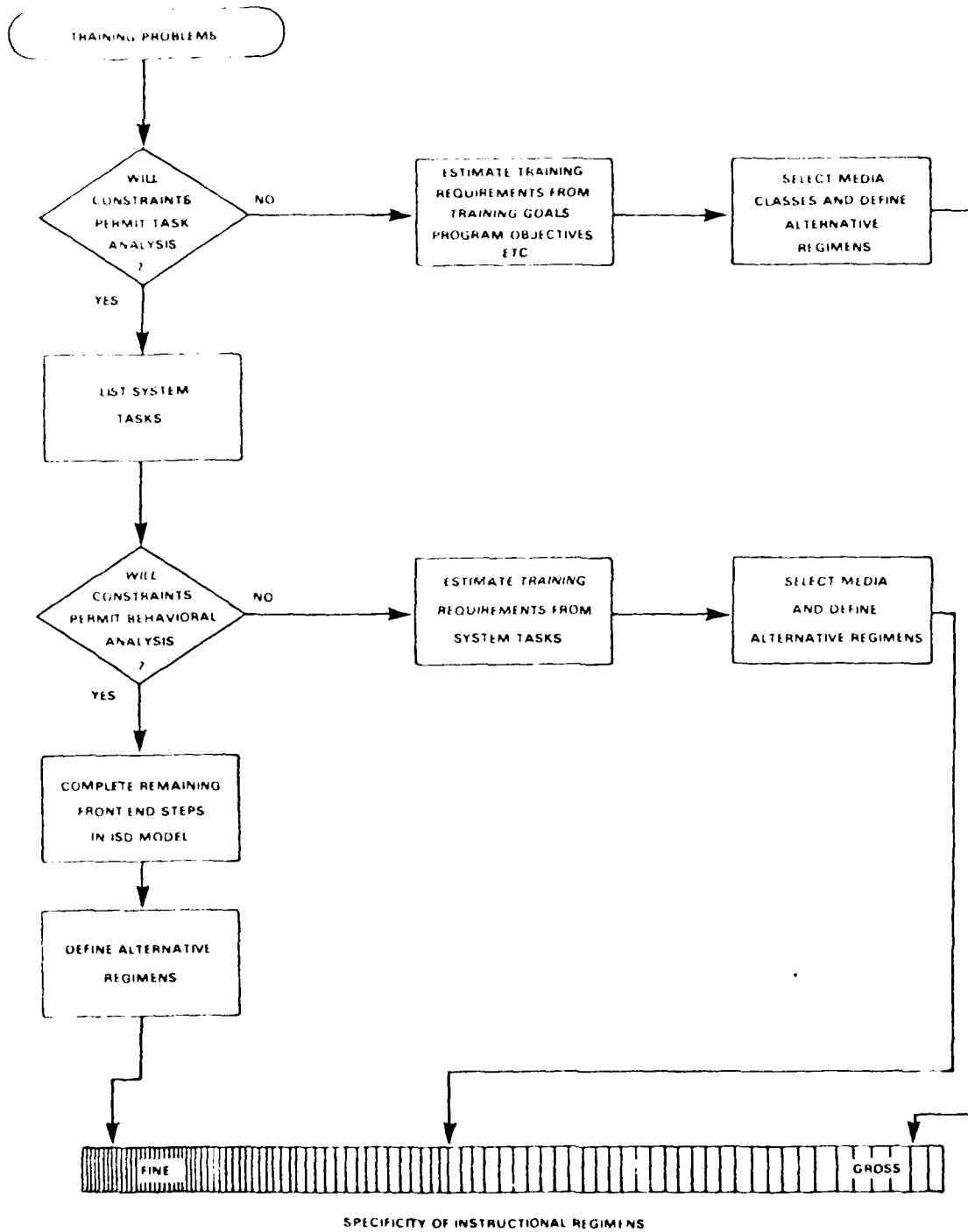


Figure 12. Levels of Specificity From Nongeneric Approaches.

# GENERIC TASKS

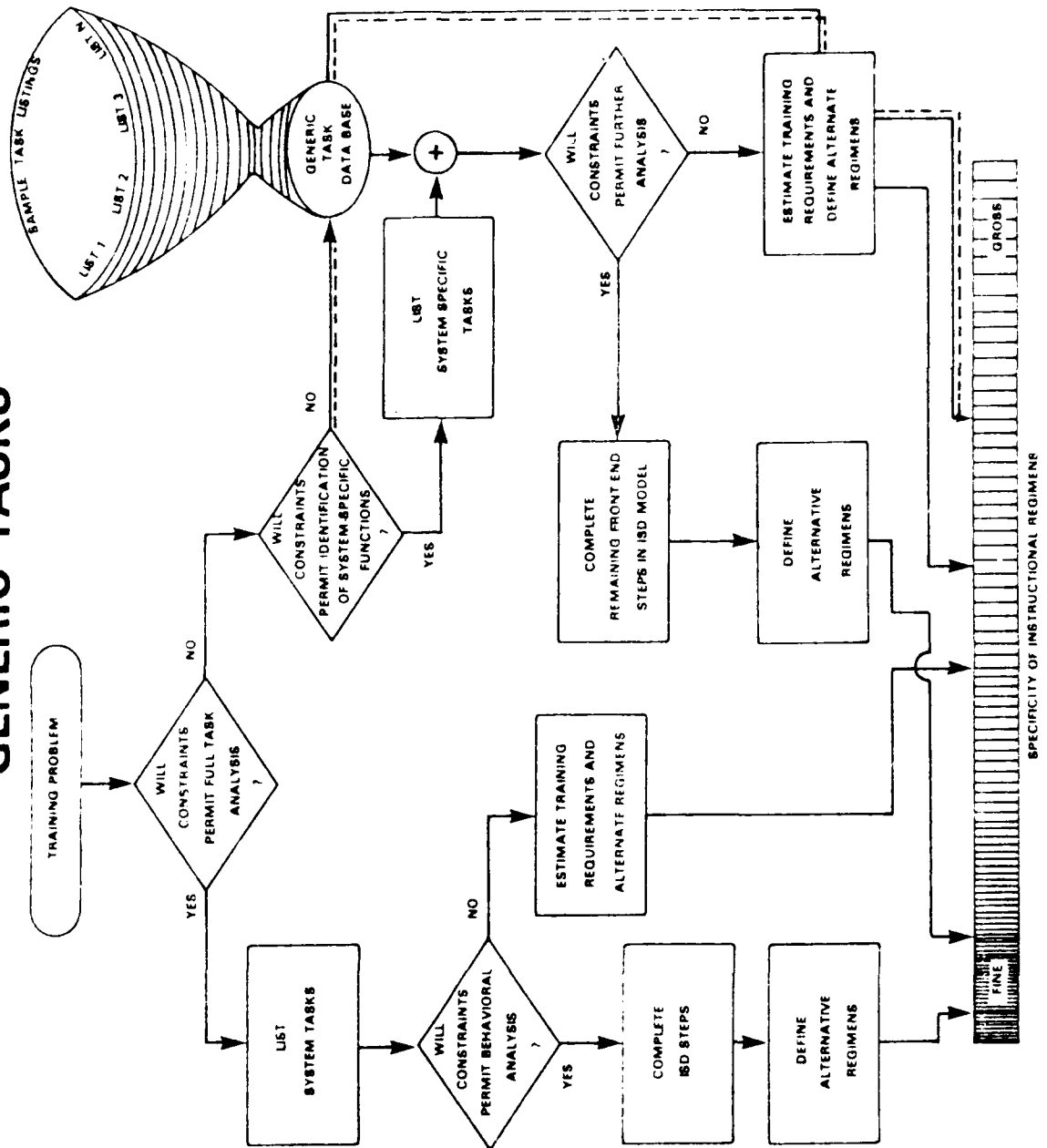


Figure 13. Levels of Specificity From Approaches Based on Generic Tasks.

The way in which this superior approach is achieved may be explained by stepping through the appropriate path in Figure 13 with an example in mind. Assume that time and/or cost constraints will not permit a full task analysis, but that the system for which a training program is needed is well understood in the sense that its primary functions are explicitly delineated. In other words, the engineering data available to the analyst stipulates what the system does under each condition in which it is to be used. Furthermore, assume that this particular system is one of a class of such systems for which task analyses have been carried out, and that the task listings of these generically related systems have been subjected to a commonality analysis thus forming a generic task data base. Now then, if the constraints to which the analyst is subject will permit an identification of system-specific functions, he may determine from these a list of tasks. As indicated in the diagram, these system-specific tasks may then be summed with the generic tasks which will yield a fairly rigorous and representative task listing. If, at this point, constraints will not permit any further analysis, the result will be a level of specificity for instructional regimens that is a little less fine than that which would have been obtained if a full task analysis had been performed. But, if constraints should allow the analyst to proceed further with behavioral and media analyses, i.e., essentially completing the remaining steps in the ISD model, then a level of specificity may be achieved which is only a little less fine than that achievable by a full-scale ISD.

In the above example, the analyst determined system-specific tasks from known system functions, combined these with generic tasks, performed behavioral and media analyses on the integrated task list, determined program, media, curricula, and other requirements from these analyses, and finally formulated alternative instructional plans to meet these requirements. This entire front-end analysis was carried out on available documentation, i.e., descriptions of system-specific functions and a generic task listing. In order to achieve a relatively high level of specificity, it was not necessary for the analyst to undertake a full task analysis. While this approach would be appropriate for either existing or emerging systems, it would seem to be especially advantageous for the latter since, in the early stages of an emerging system, all that the analyst would have available to him would be descriptions of system functions.

There is one further gain in specificity of instructional regimens that may be obtained by basing a front-end analysis on a generic task data base. If constraints permit neither a full task analysis nor identification of system-specific functions, the level of specificity that can be achieved by means of a generic task data base is significantly greater than that which would be achieved on the basis of requirements determined from training goals, program objectives, etc., which were shown to be the worst of the nongeneric approaches in Figure 12. The analysis based on generic tasks alone is illustrated in Figure 13 by the dashed line.

In summary, the availability of a generic task data base has been shown to provide the analyst with three additional approaches, each of which is superior to the only nongeneric approach that would otherwise be available to the analyst if constraints do not permit a task analysis. This fact alone would seem to constitute sufficient justification for the generic approach to analysis. However, there are further gains to be realized from the utilization of generic information.

Since the reader is now familiar with the conceptual structures represented in the diagrams being considered, it is unnecessary to discuss the remaining models in detail. It will be left for the reader to trace out the steps involved in the various paths diagrammed in Figures 14 and 15. By doing so, the reader will discover a number of interesting applications of generic information to front-end analysis. Several features of these generic models, however, should be noted.

The model diagrammed in Figure 14 assumes the existence of both a generic task data base and a generic behavioral objectives data base. As in the previous generic task model, generic tasks are determined by performing a commonality analysis on a number of task listings from similar systems. Behavioral objectives determined from these generic tasks are, themselves, generic in character and thus form a more advanced stage in the development of generic information. It may be seen in Figure 14 that the availability of a generic data base at the level of behavioral objectives yields three additional approaches to training analysis, two of which achieve relatively high orders of specificity. The third, which is the worst case, may be seen to achieve a somewhat higher level of specificity than the worst approach possible with the generic task model.

The model diagrammed in Figure 15 assumes that the development of generic information has progressed all the way to a generic media data base. Again, three additional approaches to training analysis also result from this model, and each achieves a high level of specificity. Two nongeneric approaches are represented in this model, as well as one approach involving only generic tasks. It should be apparent to the reader that, even though these models were constructed on the premise that constraints comprise the primary limitations encountered by the analyst, one approach may be more suitable than another for analysis of a training problem depending on the nature of the problem itself.

Overall, by incorporating generic information into the training analysis process through the models developed here, twelve different approaches to analysis may be realized. As compared with the three approaches based on nongeneric information, this represents a considerable increase in the avenues and outcomes that can be attained through use of generic information. The twelve approaches are listed in Figure 16. Each approach is designated by the informational components and steps contained in the analysis. They are rank ordered from one to twelve according to the specificity that may be obtained by each. It can be seen that an analysis consisting of all ISD front-end steps results in the greatest specificity of instructional regimens, and that an analysis based solely on program goals results in the lowest degree of specificity.

One further approach to training analysis has been distinguished, one involving the simultaneous development of new training technology and front-end training analysis. This approach is illustrated in Figure 17. Ordinarily, the selection of training media is not done until after training requirements have been determined. It is not unusual, however, for the analyst to be faced with constraints that make it impossible to satisfy training goals with existing media technology. For example, if training goals require the development of a simulator the cost of which exceeds by a wide margin the level of funding available, the analyst may be faced with a double problem, i.e., one involving both



## GENERIC TASKS AND OBJECTIVES

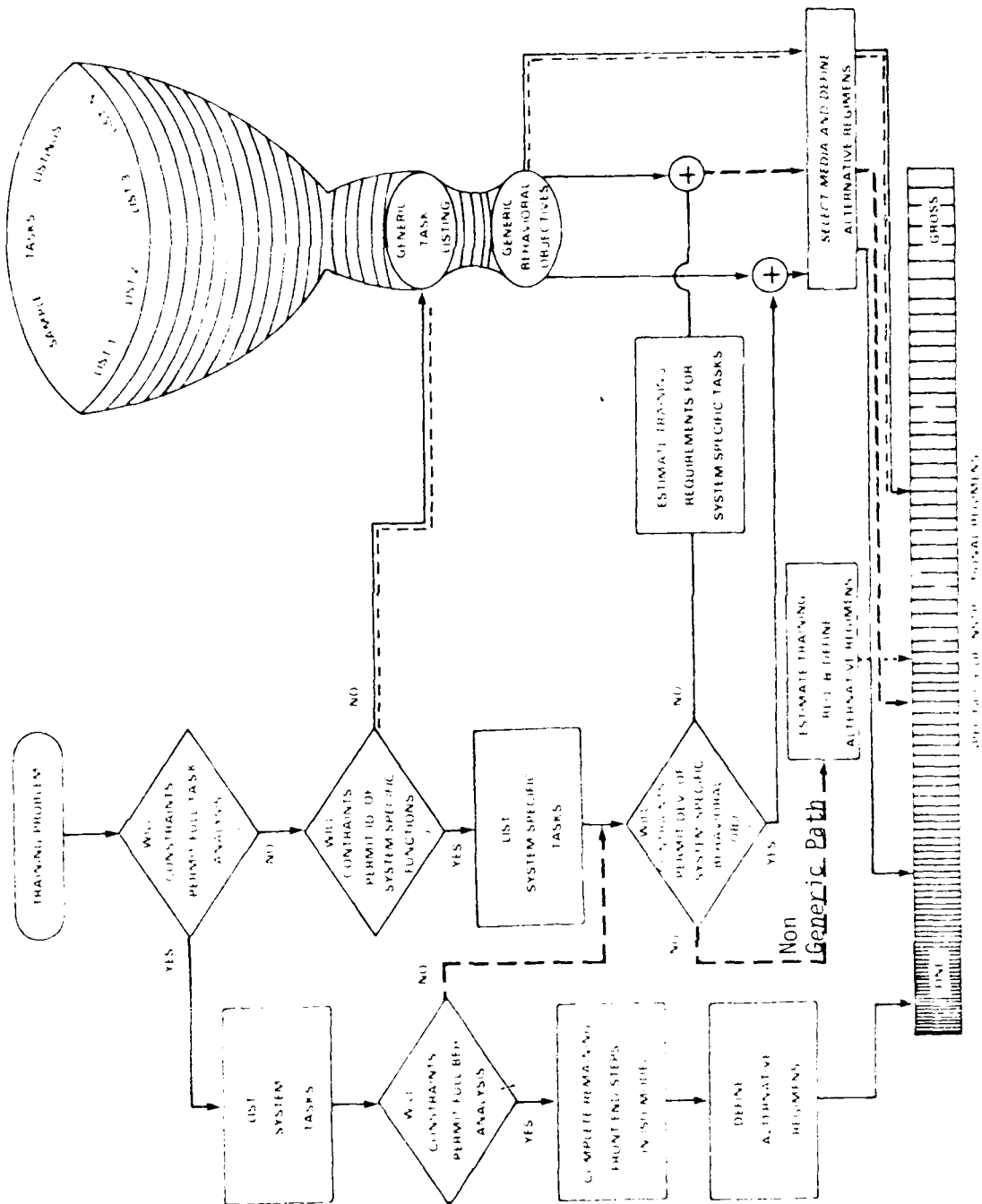


Figure 14. Levels of specificity from approaches based on generic tasks and objectives.

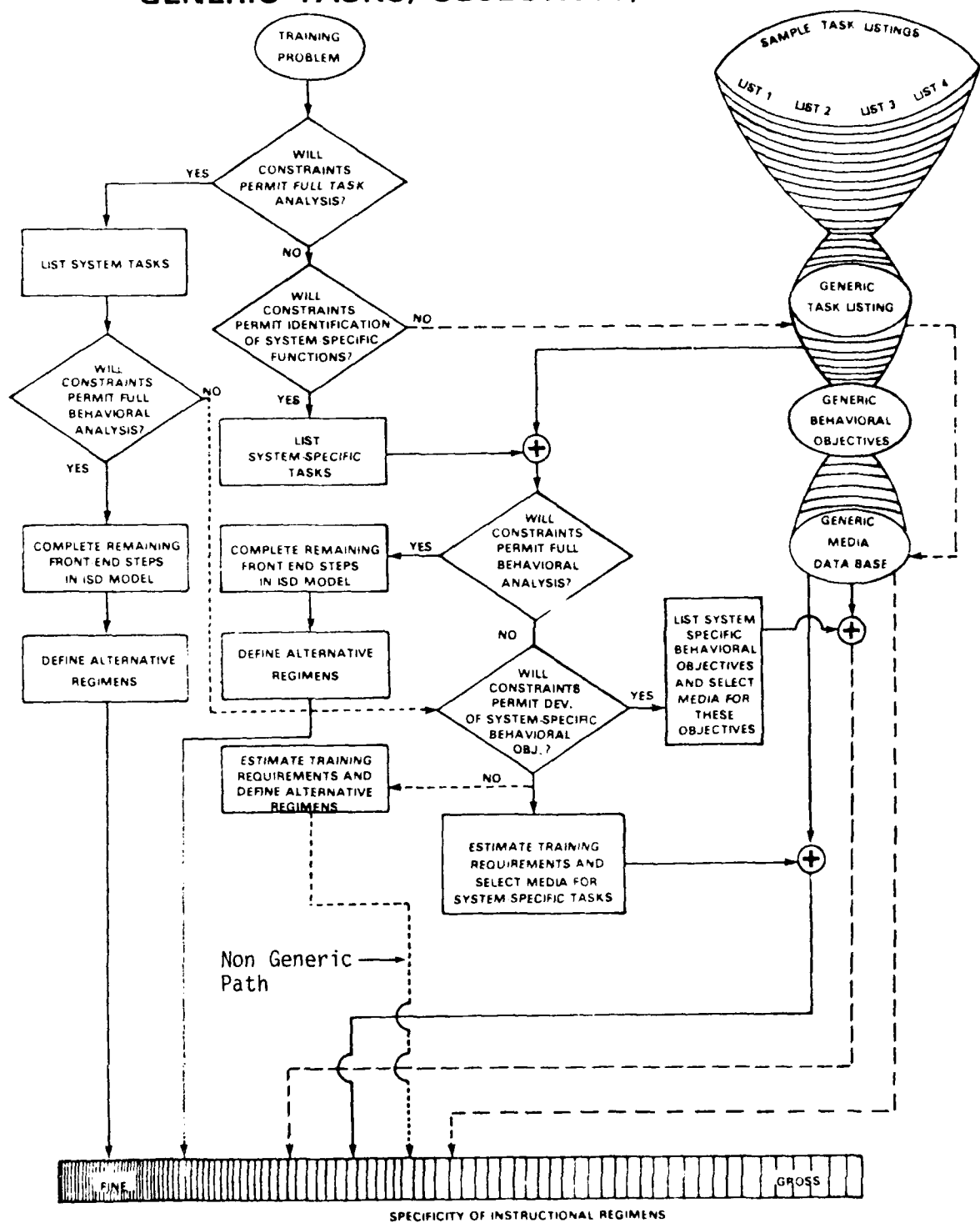


Figure 15. Levels of Specificity From Approaches Based on Complete Generic Data Base.

# INPUTS TO TRAINING REQUIREMENTS DETERMINATION ORDERED ACCORDING TO SPECIFICITY OF RESULTING INSTRUCTIONAL REGIMENS

- |  |  |
|--|--|
| 1. ALL ISD FRONT-END STEPS   | 7. EMPIRICAL TASKS   |
| 2. SYSTEM-SPECIFIC TASKS<br>GENERIC TASKS<br>REMAINING ISD STEPS   | 8. GENERIC TASKS<br>GENERIC BEHAVIORAL OBJECTIVES<br>GENERIC MEDIA |
| 3. EMPIRICAL TASKS OR SYSTEM-SPECIFIC TASKS<br>SYSTEM-SPECIFIC BEHAVIORAL OBJECTIVES<br>GENERIC BEHAVIORAL OBJECTIVES        | 9. SYSTEM-SPECIFIC TASKS<br>GENERIC TASKS                          |
| 4. SYSTEM-SPECIFIC TASKS<br>GENERIC TASKS<br>SYSTEM-SPECIFIC BEHAVIORAL OBJECTIVES<br>SYSTEM-SPECIFIC MEDIA<br>GENERIC MEDIA | 10. GENERIC TASKS<br>GENERIC BEHAVIORAL OBJECTIVES                 |
| 5. SYSTEM-SPECIFIC TASKS<br>GENERIC TASKS<br>GENERIC MEDIA   | 11. GENERIC TASKS  |
| 6. SYSTEM-SPECIFIC TASKS<br>GENERIC BEHAVIORAL OBJECTIVES  | 12. PROGRAM GOALS  |

**NOTE: IF VALIDITY IS DEGRADED BY CONSTRAINTS ON EXISTING MEDIA,  
NEW TECHNOLOGY DEVELOPMENT MAY BE USED TO RECOVER THE LOSS**

Figure 16. Components of Training Analyses Ranked According to Levels of Specificity Achieved.

# PARALLEL DEVELOPMENT OF TRAINING REQUIREMENTS AND MEDIA TECHNOLOGY

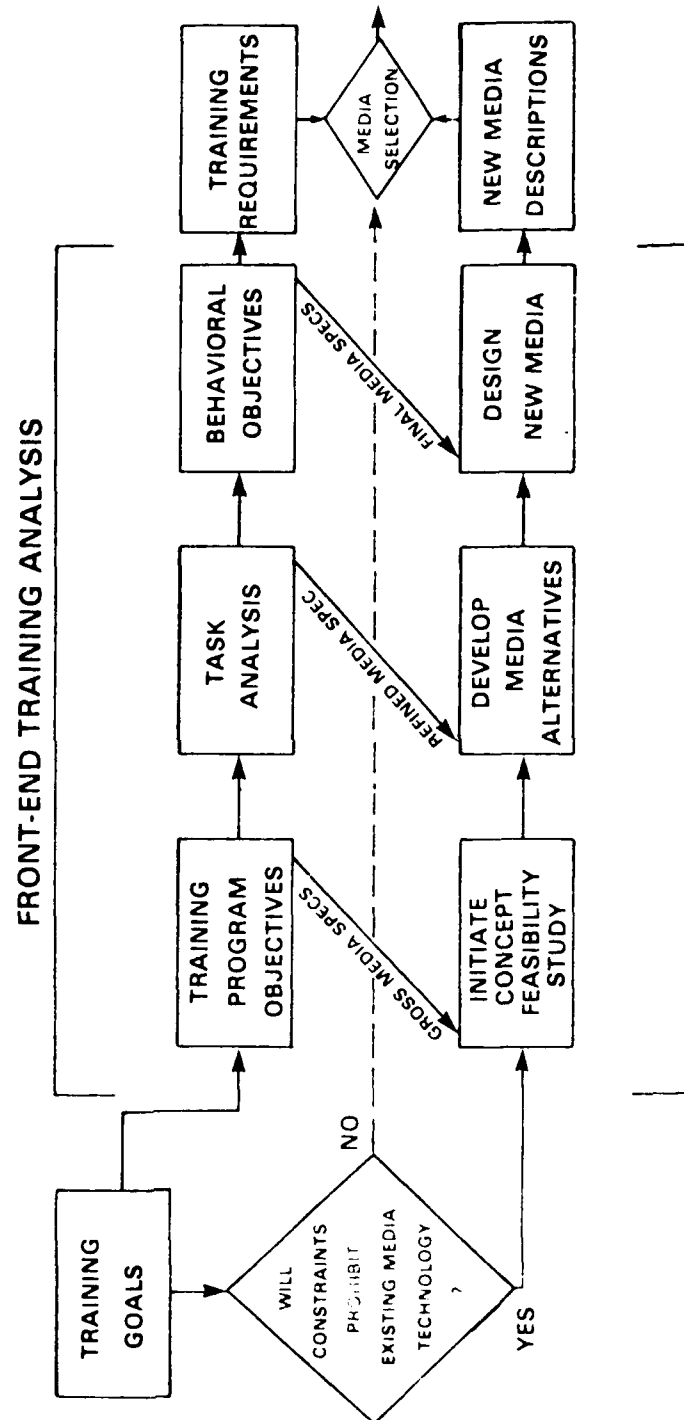


Figure 17. New Technology Approach to Training Analysis.

## NAVTRAEQUIPCEN IH-325

time and cost. Obviously, the analyst must explore alternative possibilities for obtaining a device with the required simulation capabilities at a lower cost than that inherent in the use of current technology. This may take considerable time, especially if the new media technology development has to wait until after completion of the various steps in the training analysis. It is this situation for which the model represented in Figure 17 was designed.

By developing the training requirements and new media technology in parallel, it may be possible to overcome both the time and cost constraints. As the model indicates, after completion of the first step in the training analysis, i.e., development of training program objectives, a gross specification of media requirements may be used as the basis for a feasibility study aimed at delineating the concept of simulation by new technology. Thus, as task analysis is being carried out, the feasibility study has also been gotten under way. Upon completion of task analysis, the specifications of media requirements may be further refined and these used at the end of the feasibility study for preliminary development of media alternatives. As the latter is progressing, the development of behavioral objectives is also being carried out. Completion of the latter enables formulation of the final media specifications which will then be available for design of the new media. By the time the new media descriptions are available, the training requirements will have been formulated and the process of media selection may be initiated. The new training technology development is, thus, driven by progressive refinements of media specifications at each stage of the training analysis. It is this exchange and updating of information between the engineers and the training analyst which makes it possible to carry out the new technology development within the same time frame as the training analysis. Although the model presented in Figure 17 assumes complete ISD steps for analysis, it is entirely possible that any of the generic models described previously could be substituted in place of the ISD approach.

## NAVTRAEQUIPCEN IH-325

## DISTRIBUTION LIST

Naval Training Equipment Center Orlando, FL 32813	53	Dept of Army OACSC-E CETS-3 Washington, DC 20315	1
Defense Documentation Center Cameron Station Alexandria, VA 22314	12	Asst Secretary of the Navy Research and Development Dept of Navy Washington, DC 20350	1
Commanding Officer USA Security Agency Training Center Library Ft. Devens, MA 01433	1	Office of Naval Research 102 DEP-CH Scientist Dept of Navy Arlington, VA 22217	1
Conrad Technical Library Bldg 29807 US Army Signal School Ft. Gordon, GA 30905	1	Chief of Naval Research Code 104, Research Coordinate Arlington, VA 22217	1
Chief USA Strategy and Tactics Group 8120 Woodmont Ave Bethesda, MD 20014	1	Chief of Naval Research Code 450, Dept of Navy Arlington, VA 22217	1
Commandant USA Command & General Staff College Library Division Ft. Leavenworth, KS 66027	1	Chief of Naval Operations Dept of Navy Washington, DC 20350	1
Plans Officer Psychologist Ft. Ord, CA 93941	1	Chief of Naval Operations ATTN: OPNAV 31, Dept of Navy Washington, DC 20350	1
Superintendent US Military Academy Library West Point, NY 10996	1	Chief of Naval Operations ATTN: OP 34, Dept of Navy Washington, DC 20350	1
Stimson Library Academy of Health Sciences, US Army Ft. Sam Houston, TX 78234	1	Chief of Naval Operations Manpower, System Analysis Staff OP-01B1, RM 1416 ARLX Arlington, VA 20370	1
Commanding Officer USA Engineer Research & Development Labs Library Ft. Belvoir, VA 22060	1	Chief of Naval Operations OP 56, Dept of Navy Washington, DC 20350	1
Asst Chief of Staff Forces Dept of Army, Dir of Doctrine Organization and Training DOT TR 4 Washington, DC 20025	1	Chief of Naval Operations OP-07, Dept of Navy Washington, DC 20350	1
USA Element Inter American Defense College Lib. Ft. Leslie J. McNair Washington, DC 20315	1	Bureau Naval Personnel Spec. Television ARLEX, Dept of Navy CD2, Room 3070 Washington, DC 20370	1

## NAVTRAEQUIPCEN IH-325

## DISTRIBUTION LIST

Bureau Naval Personnel Asst Chief for Education & Training Personnel CM, Dept of Navy Washington, DC 20370	1	USAF Headquarters USAF Data Svcs Ctr, AFDSC/SMD Washington, DC 20330	1
Bureau Naval Personnel Office Liaison Technical Information PERS 16, Dept of Navy Washington, DC 20370	1	Commanding Officer Naval Personnel, Program Support Activity RM 1074, Arlington Annex Washington, DC 20370	1
Scientific Advisor HQ US Marine Corps Washington, DC 20380	1	Commander Naval Air Systems Command Naval Air Systems Command Hq Washington, DC 20361	1
Technical Library DDR and E RM 3C-122, Pentagon Washington, DC 20301	1	Commander Naval Air Systems Command Naval Air Systems Command Hq Technical Library Washington, DC 20361	1
Calspan Corp. Librarian PO Box 400 Buffalo, NY 14225	1	Commander Naval Support Systems Command Naval Support Systems Command Hq SUP 0622 Washington, DC 20376	1
US Naval Research Lab ATTN: Library Washington, DC 20376	1	Commander Naval Sea Systems Command Technical Library SEA 9132 Dept of Navy Washington, DC 20360	1
National Defense College of Canadian Army Staff College Ft. Frontena Kingston, Ontario, Canada	1	Commander Naval Sea Systems Command Naval Sea Systems Command Hq CH SCI RANDD, CODE 315 Washington, DC 20362	1
Federal Aviation Agency NAFEC Library, Bldg 3 Systems Research & Development Sys Atlantic City, NJ 08405	1	Commander, Naval Sea Systems Com Naval Sea Systems Command Hq Code 335 Washington, DC 20362	1
Scientific Technical Information Off NASA Washington, DC 20546	1	Commander Naval Electronics Lab Center ATTN: Library San Diego, CA 92152	1
Commanding Officer Air Force Office Scientific Research Technical Library Washington, DC 20025	1	Naval Weapons Center 3572 China Lake, CA 93555	1

## NAVTRAEQUIPCEN IH-325

## DISTRIBUTION LIST

Chief of Naval Education & Training Code 017, NAS Pensacola, FL 32508	1	ASD/ENESS Wright-Patterson AFB, OH 45433	1
Commanding Officer Code 104, Bldg S-54 NAS Memphis (75) NATTC Millington, TN 38054	1	AFHRL/AS Wright-Patterson AFB, OH 45433	1
Commanding Officer NAVEDTRAPRODEVEN ATTN: Code OPL Ellyson Pensacola, FL 32509	1	Director Air University Library ATTN: Library Maxwell AFB, AL 36100	1
Superintendent US Air Force Academy Library (DFSLB-D) Denver, CO 80840	1	Commanding Officer School of Aviation Medicine AEROMED Library, Brooks AFB San Antonio, TX 78200	1
Commanding Officer Rome Air Development Center Document Library (TSLD) Griffis AFB, NY 13440	1	Headquarters, ESD/DRI Hanscom AFB, MA 01731	1
		6570 AMRL/HE Wright-Patterson AFB, OH 45433	1
		Air Force Institute Tech Library Wright-Patterson AFB, OH 45433	1



